NOTE NO. 146

APRIL, 1963

THE COLLEGE OF AERONAUTICS

CRANFIELD

Large Scale Metrology

- by -

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Introduction

This interim note covers some of the problems encountered in the measurement of large sizes, up to 80 inches (200 mm), during investigations carried out at the College of Aeronautics. A description of a new design of stick micrometer for internal diameters and a micrometer frame for external diameters is included, together with experimental results obtained in using this equipment.

Problems associated with measuring large sizes

These may be classified under three broad headings:-

(a) The influence of temperature on the measurement
(b) Problems associated with the stiffness of the measuring equipment.
(c) The elimination of operator feel.

(a) The influence of temperature

In practice, it may be extremely difficult to maintain both the component and measuring equipment at the internationally agreed standard of 20°C. Figure 1 shows the effect of variations in the temperature of steel components with respect to the Fundamental Tolerance value (B.S. 1916), expressed as a percentage of the tolerance grade.

The particular case illustrated is for a 3°C. change in temperature on steel components, (coefficient of expansion assumed to be 11 parts in a million/°C), manufactured to tolerance grade IT.6.

It can be seen from this graph that in the smaller sizes up to say 10 inches (250 mm), the percentage of the tolerance taken up by the change in temperature remains relatively small, but with increase in size the effect of temperature becomes increasingly significant, until at 100 inches (2500 mm) 82% of the tolerance has been consumed.

Further problems occur on large components where the time taken for their temperature to stabilise after, for example, machining operations, may be prolonged; and the handling of the measuring equipment can significantly effect the original setting of the instrument, if it is not adequately insulated.

(b) Stiffness of the measuring equipment

Appreciable errors may arise due to the lack of stiffness of the measuring equipment, particularly if it is calibrated in one plane and used for measuring in another.

(c) Elimination of Operator feel.

It would seem to be essential that some form of fiducial indicator is incorporated in the measuring equipment to avoid introducing errors due to the 'feel' of the operator. The indicator may be mechanical, electrical or pneumatic in operation.

Stick Micrometer and Micrometer Frame developed at The College of Aeronautics.

Figure 2 shows the basic measuring element of the stick micrometer. This consists of a 7/8 inch o.d. × 18 s.w.g. (22 mm × 1.2 mm) steel tube, with solid threaded anvils at each end. The end faces are lapped flat and parallel to one another, and the units may be joined together in combinations via the threaded connection. The steel tube is surrounded by a 2 inch o.d. × 0.1 inch thick (150 mm o.d. × 2.5 mm thick) fibre glass tube, with the annulus between filled with a foamed resin. The fibre glass tube, plus foamed resin, has the two fold effect of firstly insulating the steel measuring element when handled by the operator, and secondly serves to stiffen the steel tube and prevent error due to deflection of the stick micrometer.

The fiducial indicator is shown separately in Fig. 3 and consists of a Sigma microvalve and dialair unit, enabling a direct reading to 0.0001 inches (2.5 microns) to be made over a range of ±.002 inch (±5 microns).

The complete equipment is shown, in Figure 4, measuring an internal dimension of 46 inches (1200 mm).

Results obtained when using this equipment in the College standards room, and in the inspection department of an instrument firm indicate that under inspection conditions an accuracy of ±4 parts in a million may be obtained on internal dimensions. When the equipment was used, according to instructions provided by the

College, in firms engaged in engineering manufacture, an accuracy of ±7 parts in a million was obtained under workshop conditions. The accuracies quoted above are for the absolute determination of size; the repeatability of the stick micrometer was found to be ±2 parts in a million.

The insulation properties of the stick micrometer are such that holding the unit in two hands, in an ambient temperature of 20°C. over a period of 20 mins., increases its length by 10 parts in a million.

The stiffness is such that the difference in length, when supported horizontally at the Airy points and supported at positions to give maximum deflection, results in a change in length of 1 part in a million.

The micrometer frame shown in Fig. 5 is constructed from 24 s.w.g. (0.5 mm thick) steel side and channel members, stabilised with a light alloy honeycomb structure, the whole being bonded together with redux. The maximum capacity of the micrometer is 24 inches (600 mm), and the frame plus measuring head and anvil weighs 3 lb (1.4 Kg). The fiducial measuring head is again pneumatic in operation.

Preliminary tests indicate that a 24 inch (600 mm) external diameter may be determined to within ±.0001 inches (2.5 microns) (±4 parts in a million).

Conclusions

By the use of measuring equipment such as has been described in this report, and with an awareness of the precautions which are necessary with regard to temperature effects, it is thought that a substantial increase in accuracy in determining large sizes can be obtained, particularly in relation to the recommended accuracies of determination quoted in the draft BS.1916 part 3; namely ±30 parts in a million under workshop conditions and ±15 parts in a million under inspection conditions.

The investigations outlined in this report are part of the research programme being undertaken by the Department of Production and Industrial Administration in the field of metrology; it is intended to issue detailed reports on these investigations in the near future.

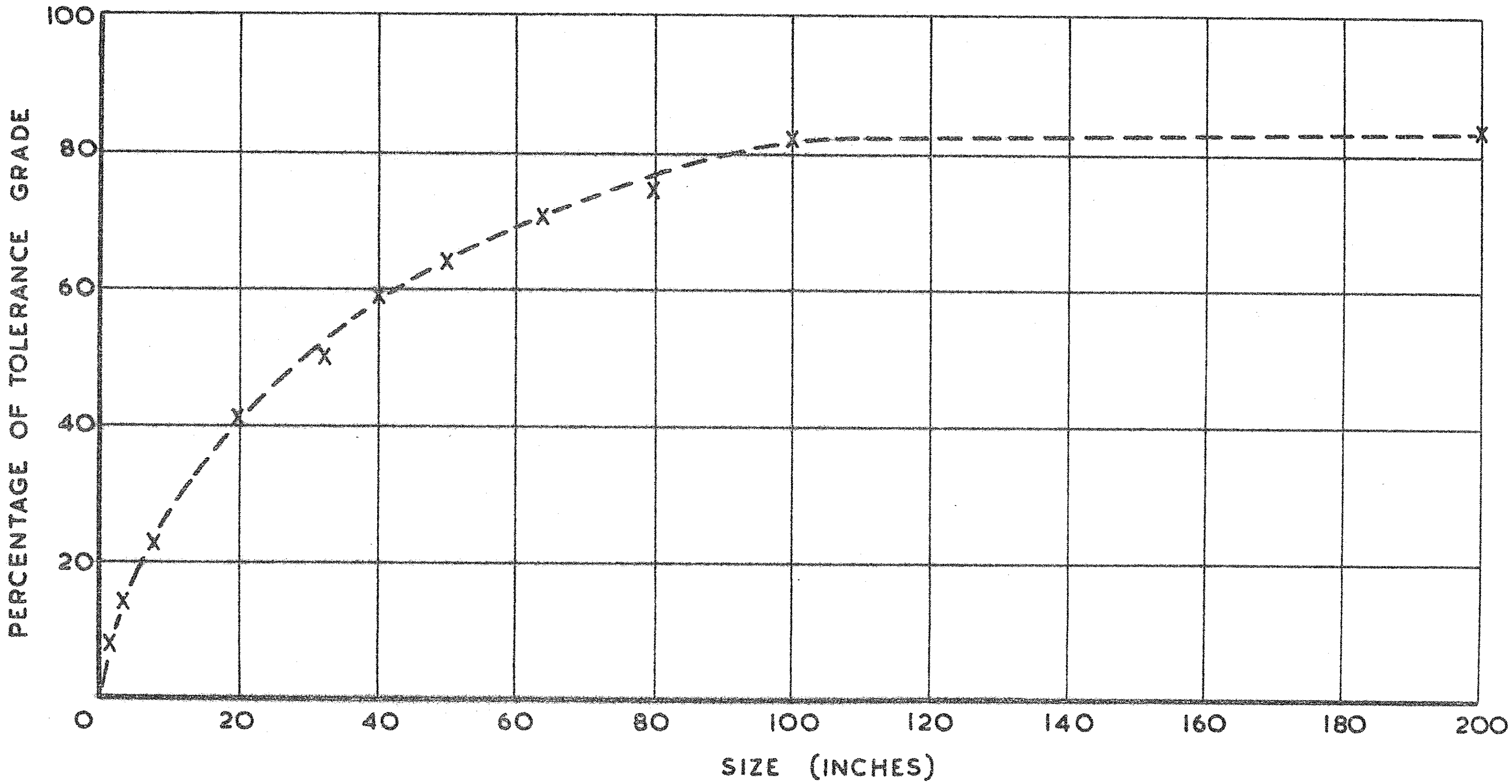

FIG.1. PERCENTAGE OF TOLERANCE GRADE IT6 TAKEN UP BY A 3 °C RISE IN TEMPERATURE ON A STEEL COMPONENT.

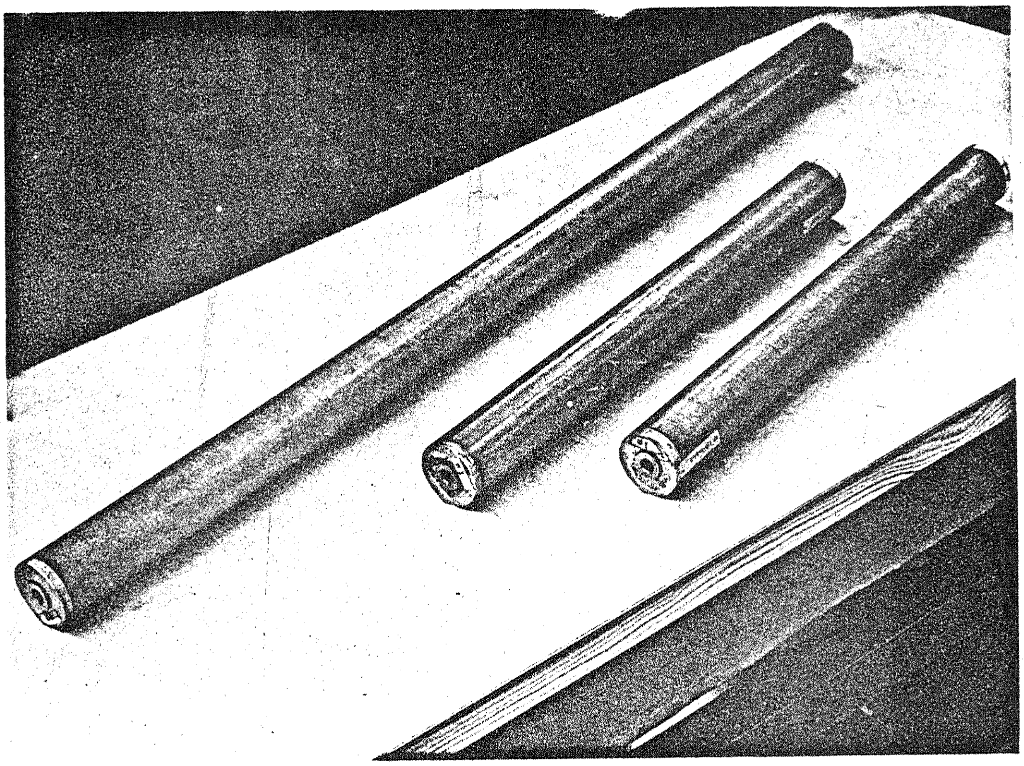

FIGURE 2.

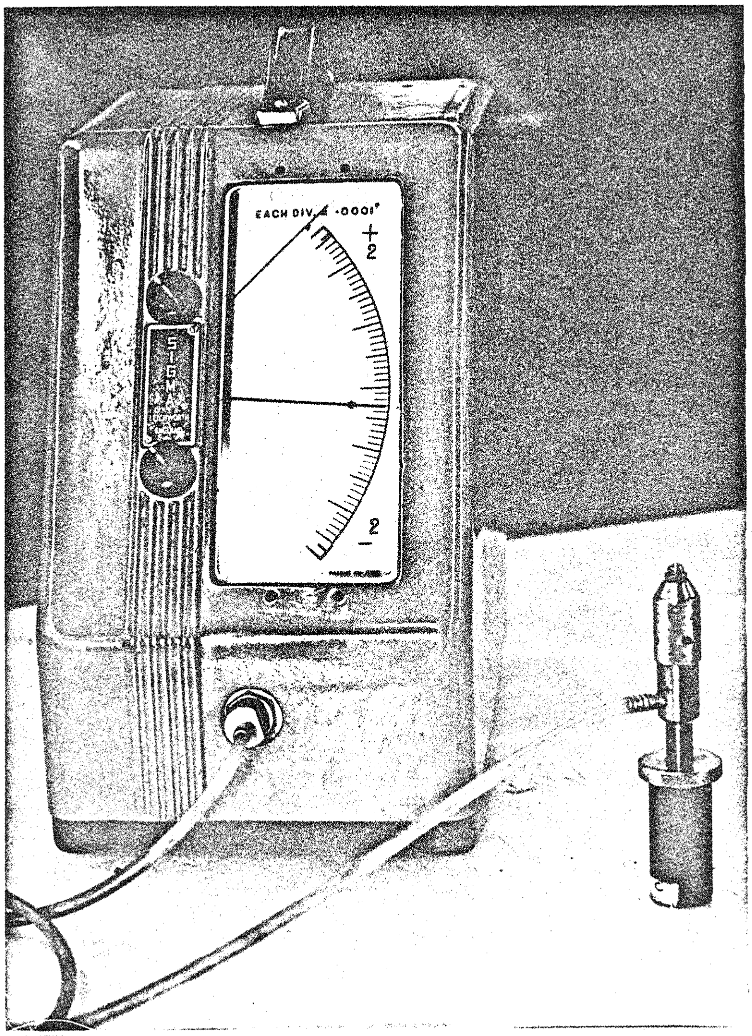

FIGURE 3.

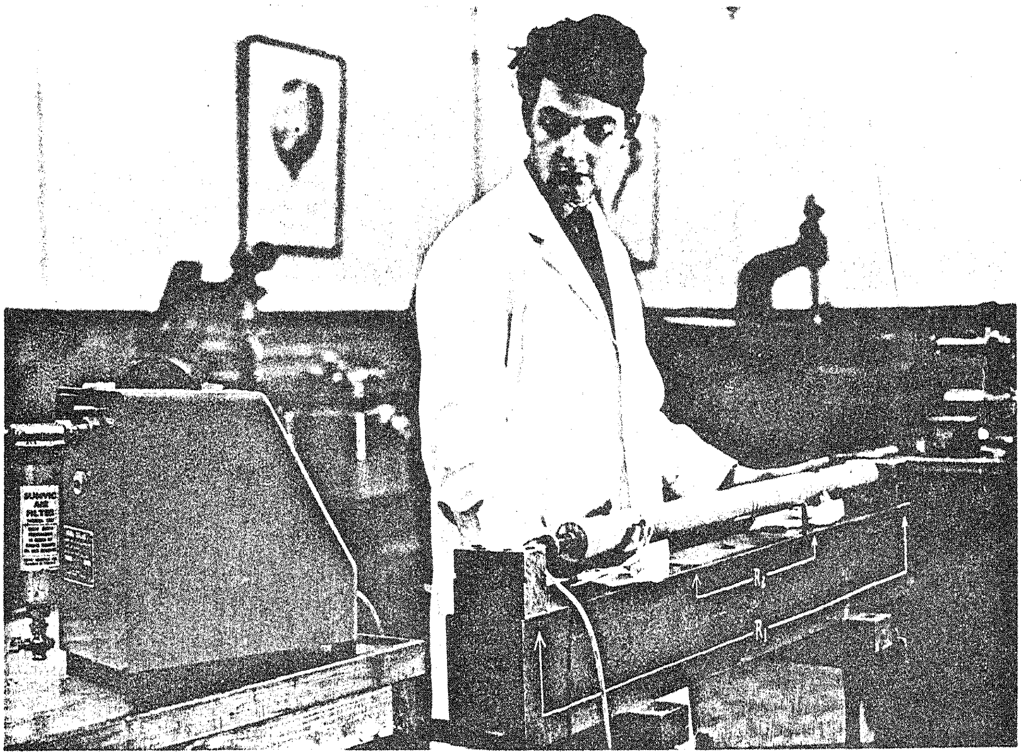

FIGURE 4.

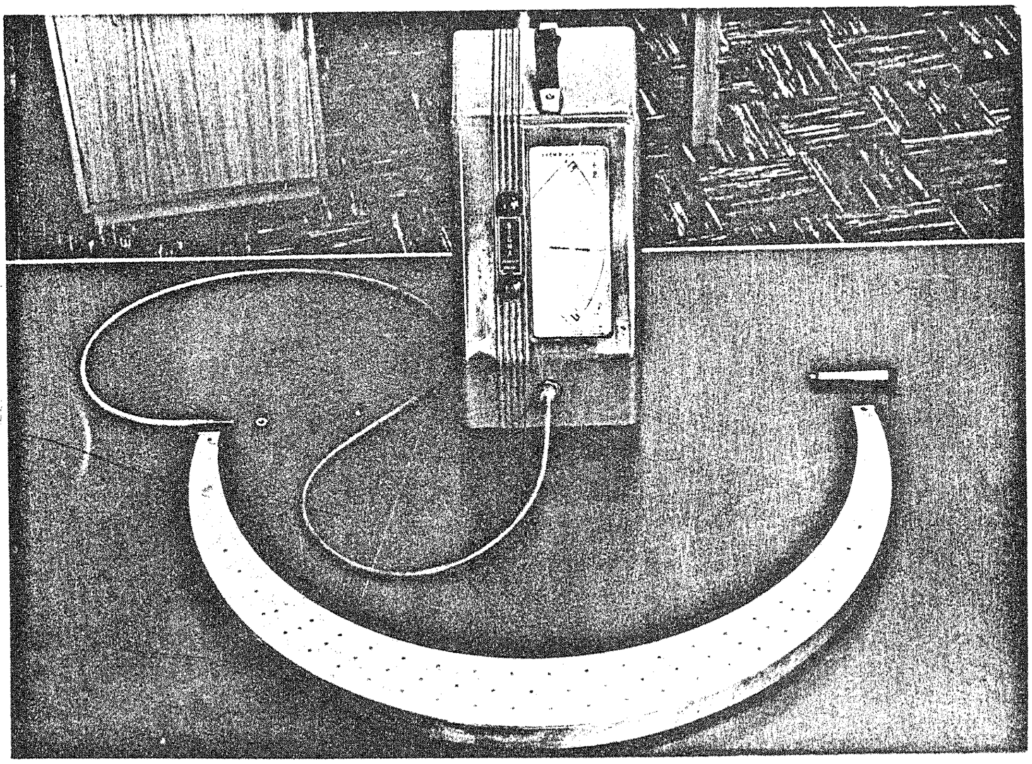

FIGURE 5.